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NOTES ON GEOGRAPHIC DISTRIBUTION

Range extension of *Bunocephalus larai* Ihering, 1930, Banjo Catfish (Siluriformes, Aspredinidae), in the Ivaí river basin, Upper Paraná River, Brazil

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Abstract. We report the occurrence of *Bunocephalus larai* in the Ivaí river basin, and expand the geographic distribution of this species to southern latitudes of the Upper Paraná river basin. Four individuals were captured through electrofishing in the Muquilão River, a tributary of the Ivaí River, Paraná, Brazil. The sampled site was within a conservation unit in the municipality of Iretama. The captures occurred in a marginal backwater of a 20–40 m wide stretch and 0.3–0.7m deep, characterized by sand/clay and leaf litter as predominat bottom substrate. Our study demonstrates the importance of ichthyofaunistic studies in headwaters of rivers.

Key words. Aspredininae, center-west Paraná, conservation, ichthyofauna inventory, Paraná River

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INTRODUCTION

The large hydrographic network makes Brazil one of the richest countries in terms of freshwater-fish diversity on the planet (Albert et al. 2020), with two of the four largest river basins in the world (the Amazon and Rio de la Plata). Most of the basins are made up of numerous small water bodies, each with distinct geomorphological and biogeographical characteristics. This results in a unique, small fish fauna in each river basin, with varied rates of endemism and rare species (Barletta et al. 2010; Albert et al. 2020). Among the largest river basins in Brazil, the Paraná River stands out (Stevaux et al. 1997). It is the second largest river basin in the country (4,685 km), which in its upper portion corresponds to around 10% of the Brazilian territory (Agostinho et al. 2007a).

Historically, ichthyofaunistic studies in freshwater environments have focused on large rivers due to the importance of economic aspects related to fishing resources (Barili et al. 2011), as well as the intense exploitation of potential hydroelectric power (Agostinho et al. 2007b). However, most of the richness of the fish fauna is attributed to the smaller streams and tributary rivers, which along with the main channel, form biogeographical units. These smaller streams and rivers are home to many endemic small and medium-sized species, some of which are rare (Castro 2021), performing varied functions in the ecosystem (Teresa and Casatti 2012; Castro 2021). According to Agostinho et al. (2007a), the upper portion of the Paraná river basin, which extends through the states of Goiás, Minas Gerais, São Paulo, Mato Grosso do Sul, and Paraná, stands out as having the most studied freshwater-fish fauna in Brazil. However, according to Langeani et al. (2007), there is still a large Linnean deficit to be filled, which was reaffirmed by Ota et al. (2015), who estimated that there are still around 35% of species to be described in the Neotropical region. Furthermore, the Wallacean deficit (when the species become locally extinct before their geographical distribution is mapped) is still present in the basin, but recent studies on species distribution range have shown the potential to overcome this problem (Hortal et al. 2015; Dagosta et al. 2024).

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The Ivaí river is located in the state of Paraná and is one of the tributaries on the left bank of the Paraná river. It drains an area of 35,845 km^2 and is approximately 685 km long, covering 102 municipalities, and is considered the second largest river basin in the state of Paraná (Parolin et al. 2010). Previous ichthyofaunal studies in the Ivaí river basin, such as that by Frota et al. (2016), recorded 118 fish species in the basin, while dos Reis et al. (2020) added new records over the following four years, totaling 132 species. The Ivaí sub-ecoregion has few species that are common in other sub-ecoregions due to geomorphological aspects that act as natural barriers, isolating the ichthyofauna of the Ivaí river basin from other adjacent rivers (Frota et al. 2016; dos Reis et al. 2020). This fact is also corroborated by greater endemism found in the Ivaí compared to the other river basins of the Upper Paraná River (Frota et al. 2016).

A total of 440 species and 178 genera were recorded by dos Reis et al. (2020) across different sub-ecoregions of the Paraná State; however, *Bunocephalus larai* Ihering, 1930 was recorded only in the sub-ecoregion of Paranapanema. *Bunocephalus* Kner, 1855 is the genus with the largest number of species in the Aspredinidae (Carvalho et al. 2015). This family has a unique and easily recognizable its body shape, and aspredinids are popularly known as "banjo catfish". There are 13 recognized genera in the family, and all are endemic to South America (Fricke et al. 2024). Within Aspredinidae, the greatest species richness of *Bunocephalus* is found in the river basins of northern South America, mainly in the basin of the Amazon River (Fricke et al. 2024). In the river basins of southern South America, only four species are currently known in the La Plata River basin, *Bunocephalus doriae* Boulenger, 1902 from the basins of the lower Paraná, Paraguay, and Uruguay rivers; *Bunocephalus erondinae* Cardoso, 2010, from the Laguna dos Patos System; and *Bunocephalus larai* Ihering, 1930 and *Bunocephalus hertzi* Esguícero, Castro & Pereira, 2020 both from the Upper Paraná River basin (Fricke et al. 2024). Considering the already recorded distribution of *B. larai*, in our study we aimed to: i) record the first occurrence of the species in the Ivaí river basin, in a Conservation Unit in the municipality of Iretama, Paraná, Brazil, and ii) expand the records of its distribution in the southernmost part.

METHODS

The Muquilão River is a fourth-order river that runs along the border of the Dama do Abismo Municipal Ecological Station, located in the central-western region of the state of Paraná (Figure 1). It is situated on

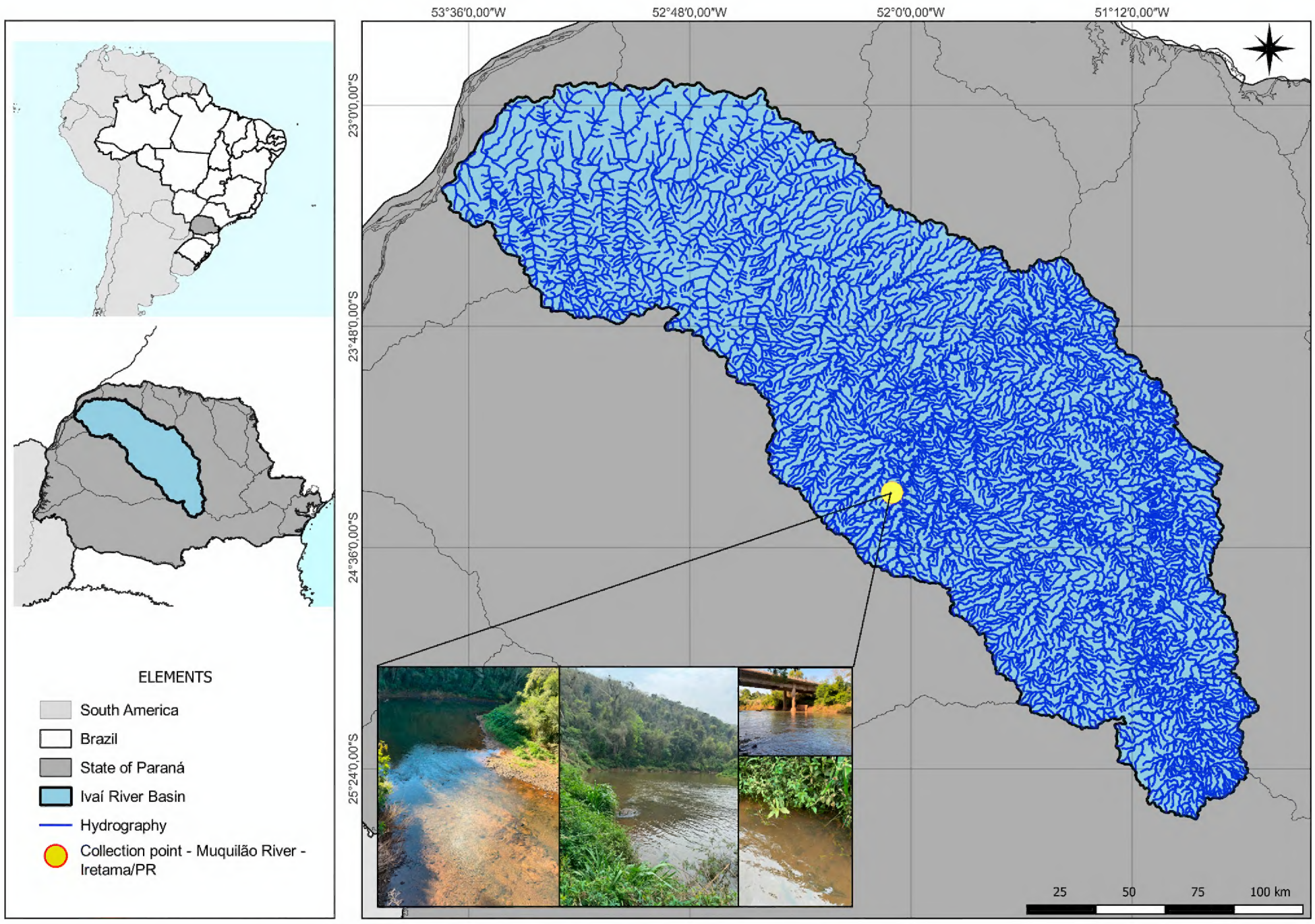

Figure 1. Study area in the context of the Ivaí river basin, and the sampling site on the Muquilão River, Iretama, Paraná.

the left side of the Upper Ivaí River hydrographic basin (Paraná 2010). The region's climate is classified as humid subtropical, with hot and humid summers, where temperatures exceed 22 °C, and more than 30 mm of rain during the driest month (Nitsche et al. 2019). The predominant vegetation at the study site consists of Mixed Ombrophyllous Forest and Semideciduous Seasonal Forest, and the soils are classified as neosols, latosols, and nitisols (Bhering et al. 2007).

The sampling site on the Muquilão River, just below the bridge that passes over PR 487, is surrounded by small rural agricultural properties. Primarily plantings are soybeans and corn in the summer, and corn, wheat, and oats in the winter. Additionally, there is livestock, including dairy and beef cattle, present on many properties. In the section downstream of the Muquilão River bridge over PR 487, on the left side of the sampled point, is the Dama do Abismo Municipal Ecological Station, which presents well-preserved riparian vegetation, with several large tree species, generating partial shading over the riverbed. On the bank on the right side, there is the presence of riparian vegetation with a preservation width of approximately 15–30 m wide, but this area is under great pressure from activities linked to agriculture on neighboring properties. The river channel is characterized by meandering stretches, including riffles, pools and backwaters mesohabitats. The collection stretch is 30-40 m wide and has an average depth of 0.3-0.7 m. The riverbed is predominated by cobbles, pebbles, and boulders substrate, with sand/clay and leaf litter along its edges.

During our study, five samples were taken (January, March, and October 2022 and January and March 2023) at one site on the Muquilão river (Figure 1). We used the electrofishing technique over a 60-m stretch. The fishing equipment used consisted of a portable alternating current generator (220 V, 50–60 Hz, 3.4–4.1 A, 2.2 kva), connected to two electrodes by a 60m long flexible cable. The electrodes consisted of two circular aluminum-framed paddles and a mesh bag with 1.5 mm meshes. Two consecutive passes were made from downstream to upstream. After collection, the fish were anesthetized (Eugenol, two drops per liter) following the Animal Experimentation Ethics Committee of the Universidade Estadual do Oeste do Paraná (protocol number 14-22), packed in plastic bags, and after euthanasia, fixed in 10% formaldehyde and transported to the laboratory. The fish were collected using a license from the Chico Mendes Biodiversity Institute (no. 25039).

The fish were identified to genus following the key provided by Friel (1994) and using the diagnosis of the redescription of *B. larai* from Esguícero et al. (2020), specifically literature and comparative material. Morphometric data were performed following the methodology proposed by Carvalho et al. (2015), with digital calipers (precision of 0.1 mm), and the measurement was made from point to point. Individuals of *B. larai* were photographed under natural conditions after capture (Figure 2) and after fixation (Figure 3) and deposited in the fish collection at LIEB (Laboratório de Ictiologia e Ecologia e Biomonitoramento), Universidade Estadual do Oeste do Paraná, Cascavel, Paraná (uncatalogued specimens), and NUP (Coleção ictiológica do Nupélia) Universidade Estadual de Maringá, Maringá, Paraná.

RESULTS

Bunocephalus larai Ihering, 1930

Figures 1–4, Table 1

New records. BRAZIL – Paraná state • Upper Paraná basin, Rio Ivaí sub-basin, Rio Corumbataí, Rio Muquilão; 24°24′31.87″S, 052°02′34.06″W; 430 m alt.; 26 Jan. 2023; R. Delariva leg.; 1 spec., 58.4 mm SL,

Figure 2. Live specimens of *Bunocephalus larai* in the Muquilão River, Ivaí river basin, Upper River Paraná, Iretama, Paraná, Brazil.

Figure 3. *Bunocephalus larai*, NUP 25165, 58.4 mm SL, from Muquilão River, Ivaí river basin, Upper Paraná River, Iretama, Paraná, Brazil.

NUP 25165 • same locality; 24 Mar. 2023; R. Delariva leg.; 1 spec., 51.7 mm SL, NUP 25166 • same locality; 20 Jan. 2022; R. Delariva leg.; 1 spec., 40.6 mm SL, uncatalogued • same locality; 26 Jan. 2023; R. Delariva leg.; 1 spec., 54.5 mm SL, uncatalogued.

Identification. The Muquilão River specimens fit the diagnosis of *B. larai*, as they present a maxillary barbel which slightly extends beyond the origin of the pectoral fin, approximately 1–2 times the orbital diameter, with 82.1–97.8% of the head length (vs. maxillary barbel reaching middle point of the adpressed pectoral-fin spine, with 103.9–129.7% of the head length in *B. doriae*, or not surpassing pectoral-fin insertion, with 54.6–67.4% of the head length in *B. hertzi*); and the presence of 10 branched caudal-fin rays (vs. nine branched caudal-fin rays in *B. mineirim*). Additionally, our specimens from Muquilão river can be distinguished of *B. hertzi*, the only other congeners that occur in the Upper Paraná River, by the skull ornamentation, which is composed of four bony protuberances between the posterior end of the occipital and the origin of the dorsal fin: one protuberance in the posterodorsal end of suppraoccipital, two protuberance along the dorsal edge of complex centrum of Weberian apparattus, and one prominent protuberance at the dorsal face of the middle nuchal plate (vs. five protuberances in *B. hertzi* between the posterior end of the occipital and the origin of the dorsal fin: one protuberance in the posterodorsal end of supraoccipital, three protuberances along the dorsal edge of the complex centrum of Weberian apparatus, and one prominent protuberance at the dorsal face of the middle nuchal plate). Morphometric data are presented in Table 1. Only three specimens were used in the morphometric and meristic data, due to the poor fixation of one specimen.

Meristics data. Dorsal-fin rays i, 4 (3 spec.); anal-fin rays iii,5 (2 spec.) and iii, 4 (1 spec.); pectoral-fin rays i, 5 (3 spec.); pelvic-fin rays i, 5 (3 spec.); and caudal-fin rays i, 8, i (3 spec.).

Table 1. Morphometric data of *Bunocephalus larai* collected in the Muquilão River, Ivaí River basin, Upper Paraná River basin. SD = standard deviation; *n* = 3.

Measurements	Min	Max	Mean	SD
		Three specimens		
Standard length (mm)	41.5	58.4	—	—
Percent of SL				
Head length	24.4	26.0	25.1	0.84
Pre-pectoral length	23.2	25.3	24.4	1.07
Cleithral width	29.6	31.2	30.7	0.91
Maximum head depth	12.4	14.1	13.0	0.94
Pectoral-spine length	23.3	26.9	25.3	1.85
Distance between coracoid processes	18.1	20.8	19.4	1.35
Coracoid process length	12.4	15.6	13.8	1.63
Distance between cleithral processes	23.3	26.1	25.1	1.58
Cleithral process length	10.2	13.6	12.0	1.70
Pre-dorsal length	43.3	44.5	44.1	0.71
Depth at dorsal-spine insertion	8.8	15.1	12.6	3.30
Dorsal spine length	15.5	17.2	16.1	0.91
Pre-pelvic length	44.4	48.0	46.0	1.80
Length of 1st unbranched pelvic-fin ray	12.3	13.2	12.7	0.49
Pre-anal length	62.7	64.5	63.8	0.96
Anal-fin base length	12.8	17.8	16.0	2.77
Caudal-peduncle length	18.5	22.0	20.6	1.82
Caudal-peduncle depth	4.9	5.4	5.2	0.27
Caudal-fin length	20.4	25.6	23.5	2.69
Percent of head length				
Snout length	25.9	29.6	27.4	2.01
Eyediameter	5.7	8.0	6.6	1.21
Interorbital width	30.8	32.6	31.4	1.00
Maxillary-barbel length	82.1	97.8	91.2	8.14
Distance between anterior nares	18.3	18.9	18.7	0.34
Distance between posterior nares	28.9	29.2	29.1	0.19
Mouth width	34.4	35.4	34.8	0.52

DISCUSSION

Ihering (1930) described *Bunocephalus larai* in the Piracicaba River, state of São Paulo, Brazil, and Esguícero et al. (2020) recently provided a diagnosis and redescription of the species. In the Paraná state, it has been only found in the Tibagi river basin (Esguícero et al. 2020; dos Reis et al. 2020). In our study, four individuals that fit the diagnosis of the species were found in the Muquilão River, in the municipality of Iretama, center-west of the state of Paraná. With the occurrence of the species for the first time in the Ivaí river basin, we expand the geographic distribution of *B. larai* to around 200 km southwest (Figure 4).

The Ivaí river basin has peculiar geomorphological aspects and stands out in the Upper Paraná River as an area of high endemism (Frota et al. 2016, 2022). It has many natural barriers, which permeate the isolation and sharing of fish fauna with other basins (Frota et al. 2016; Depra et al. 2018). Along with this factor, the scarceness of studies on ichthyofauna in small tributaries and difficult access areas, such as headwaters with irregular relief (Araújo et al. 2011; Delariva and da Silva 2013) are likely explanations for the absence of records of the species in previous inventories, and the reason for species being shared with other river basin.

Species of Aspredinidae are commonly known as banjo catfish due to their general body shape, depressed head, and slender caudal peduncle (Myers 1960). All species of the family are endemic to the South America (Fricke et al. 2024), where they occur in habitats ranging from shallow backwaters to deep channels (Friel 2003). Aspredinids have unusual characteristics, such as warty skin, which is periodically

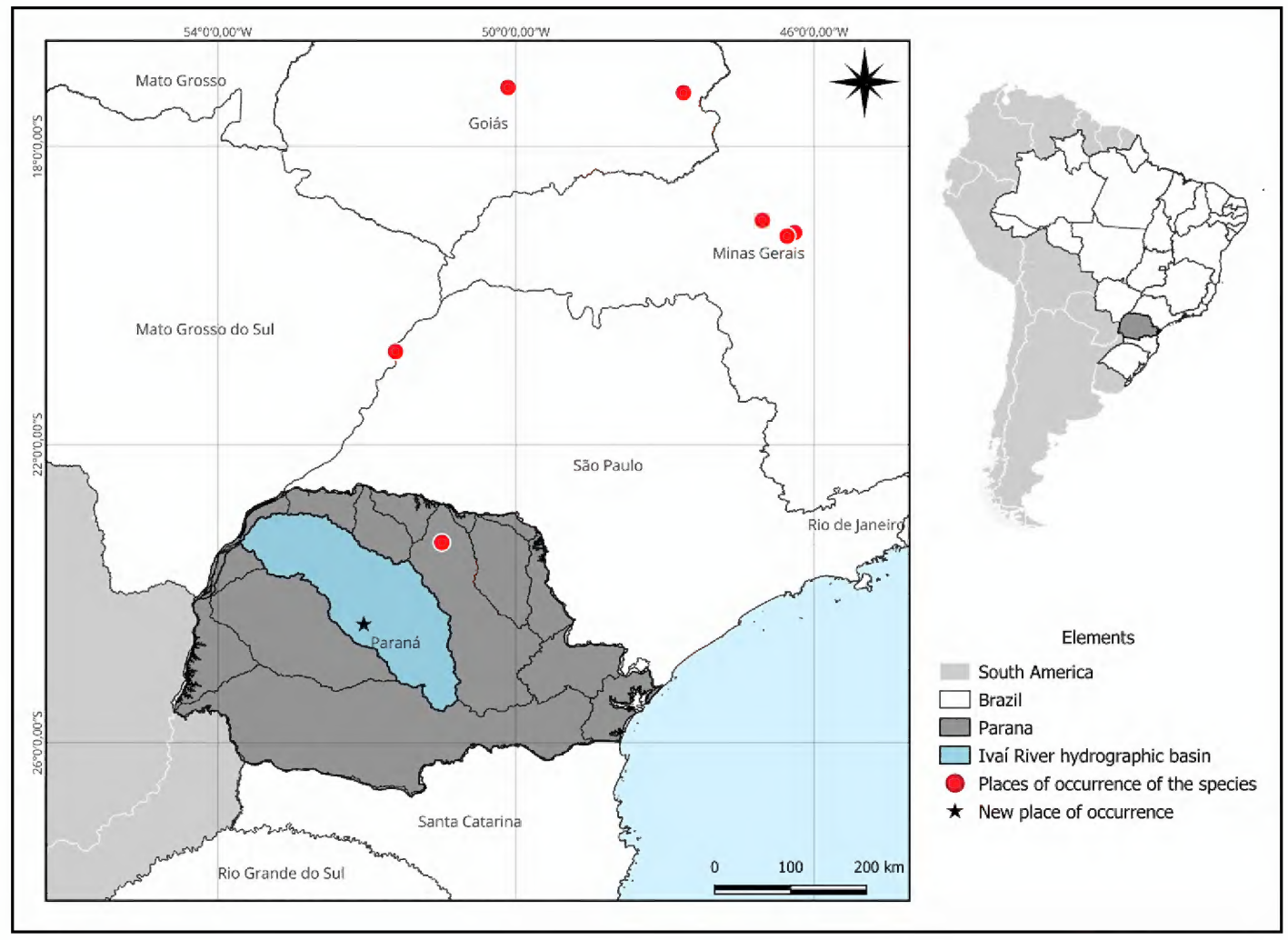

Figure 4. Current distribution map of *Bunocephalus larai* Ihering, 1930, with the new record in the Ivaí river basin (★), Paraná, Brazil.

shed like a snake, and they can emit a stridulatory sound when agitated (Friel 1989). *Bunocephalus* are omnivores, whose stomachs generally contain aquatic invertebrates, terrestrial insects, and detritus (Melo et al. 2004). They inhabit the benthic portion of rivers and have behaviors that make their capture difficult with traditional methods using gill nets and sieves, as they explore leaf litter and are buried in the substrate (Friel 2003). This behavior and habitat use may also explain the sparse and scattered record of this genus in the basins of the Upper Paraná River.

The electrofishing methodology employed in a stretch of rapids in the Muquilão River, where the average depth exceeded 1 m, may have contributed to the record of the species. However, the hypothesis of low abundance and rarity of the species cannot be ruled out, since previous inventories carried out in streams in the same region and with the same methodology used in this work, encompassing the Ivaí, Piquiri and Iguaçu basins, reported no records of *B. larai* or any *Bunocephalus* species (dos Reis et al. 2020; Larentis et al. 2022). The low number of individuals sampled (four individuals in five samplings over two years) reinforces this assumption.

Despite the presence of a conservation unit downstream of the BR 487 bridge over the Muquilão river, the immediate region where we collected *B. larai* has suffered constant human pressure, mainly due to agricultural activities. Degradation of habitat includes, for example, the removal of the minimum strip of riparian forest required by law (Casatti 2010), which leads to greater input of nutrients and pollutants into the aquatic environment. Therefore, considering the low abundance of *B. larai* at our survey site, it is essential to adopt measures to preserve the area and basin where the species occurs.

Our new data on *B. larai*, the first records from the Ivaí river basin and specifically from the Muquilão River, highlights the importance of monitoring and of preserving areas with natural flow characteristics, such as the undammed stretches in the Upper Paraná River. In this context, the Ivaí river basin has been the subject of important scientific and public debate, as well as movements by organized civil society to prevent the alarming number of small hydroelectric dams (dos Reis et al. 2020). We hope that our new data on this *B. larai*, a low-abundance species, will contribute to the database to assist in the planning and establishment of new priority areas for the conservation of rare species, as highlighted by Frota et al. (2021) elsewhere.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

Samples were approved by the Animal Experimentation Ethics Committee of the Universidade Estadual do Oeste do Paraná (protocol number: 14-22).

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Author contributions

Conceptualization: JTA, RLD. Data curation: JTA, RBR, RLD. Formal analysis: JTA, RBR, LLW, RLD. Funding acquisition: RLD. Investigation: JTA, RBR, LLW, RLD. Methodology: JTA, RBR, RLD. Resources: RLD. Supervision: RLD. Visualization: JTA, RBR, LLW, RLD. Project administration: RLD. Software: JTA, RBR, RLD. Validation: LLW, RLD. Writing – original draft: JTA, RBR, LLW, RLD. Writing – review and editing: JTA, RBR, LLW, RLD.

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Data availability

All data that support the findings of this study are available in the main text.

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